Oceans Melting Greenland GLISTIN-A Elevation Data, Ver. 1 User's Guide

Data Set

OMG Ice GLISTIN-A Level 3 Data Ver. 1
https://podaac.jpl.nasa.gov/dataset/OMG_L3_ICE_ELEV_GLISTINA

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Abstract

Global sea level rise is a major environmental challenge of the 21st Century. NASA's Oceans Melting Greenland (OMG) mission seeks to improve estimates of sea level rise by addressing the question: To what extent are the oceans melting Greenland's ice from below? **This OMG dataset contains 50m horizontal resolution digital elevation models (DEMs) of Greenland Ice Sheet marine-terminating glaciers that can be used to quantify ice volume change near glacier termini.**

Citation

This research was carried out by the Jet Propulsion Laboratory, managed by the California Institute of Technology under a contract with the National Aeronautics and Space Administration. Use of this data should be cited as follows:

> *OMG Mission. 2020. Glacier elevation data from the GLISTIN-A campaigns. Ver. 1. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at https://dx.doi.org/10.5067/OMGEV-GLNA1.*

Contact

For questions about access to the data product please email podaac@podaac.jpl.nasa.gov or visit the PO.DAAC forum. For questions about the data product itself please email Ian Fenty, Ian.Fenty@jpl.nasa.gov or Mike Wood, Mike.Wood@jpl.nasa.gov

Introduction

Between 2016 and 2019 the OMG mission used the *GLacier and Land Ice Surface Topography Interferometer-Airborne* (GLISTIN-A) radar to measure surface elevations around the periphery of the Greenland Ice Sheet using Ka-Band (8.4 mm wavelength) single-pass interferometry. The GLISTIN-A radar produced high spatial resolution (~3 m), high-precision (< 50 cm) height maps of Greenland's coastal glaciers. The GLISTIN-A radar was mounted in a pod under a NASA Gulfstream III airplane. Operating at Ka-Band enhances interferometric accuracy, reduces penetration into the top layers of snow and firn and limits signal attenuation in the atmosphere.

The location, orientation, and length of GLISTIN-A swaths were designed to map the last few kilometers of outlet glaciers. In the ideal case, the near-nadir edge of the GLISTIN-A swaths fall just offshore of an outlet glacier, capturing its last several kilometers and terminus. The majority of swaths were flown *perpendicular* to the direction of glacier flow, capturing the termini of many different glaciers in each data collection pass. A small number of additional swaths oriented *parallel* to the direction of glacier flow were included in the mission to map inland glacier elevations several 10s of km upstream from their termini.

This Level 3 (L3) dataset was created to facilitate analysis of the year-to-year glacier surface elevation changes. Improvements over the Level 2 (L2) GLISTIN-A elevation dataset, available on the JPL UAVSAR website (uavsar.jpl.nasa.gov/), include:

- swath numbering scheme (1 to 81)
- equal-area grids with 50 m postings
- swath-centered UTM map projections
- a data quality flag data layer
- an ancillary geoid data layer

Campaigns

The OMG mission flew four annual springtime campaigns (1) March 2016, (2) March 2017, (3) March 2018 and (4) March-April 2019. Every campaign was conducted by the GLISTIN-A Instrument Team aboard the Grumman Gulfstream III (G-III) aircraft.

Level 3 Product Generation

The digital elevation maps (DEMs) in these products were created by bin-averaging L2 swath elevation data at ~3 m posting and WGS84 coordinates (EPSG:4326) to L3 gridded data at 50 m posting and swath-centered UTM coordinates (e.g., EPSG:32621 for swaths centered between 54W and 60W). Transformation from L2 data to the L3 product was done using the Python 3 package **resample_GLISTIN_DEMs,** available from the NASA github page https://github.com/NASA/resample_GLISTIN_DEMs.

Note: Instructions for users to download and bin-averaging L2 data to different grid resolutions or map projections is provided in the product README file.

Swath Numbering Scheme

The swath numbering scheme is ordered from 1 to 81 from southern Greenland (Swath 1) and proceeding counter-clockwise around Greenland (Figure 1).

Note that swaths 43, 44, and 56-65 were not collected in 2016 due to instrument failure.

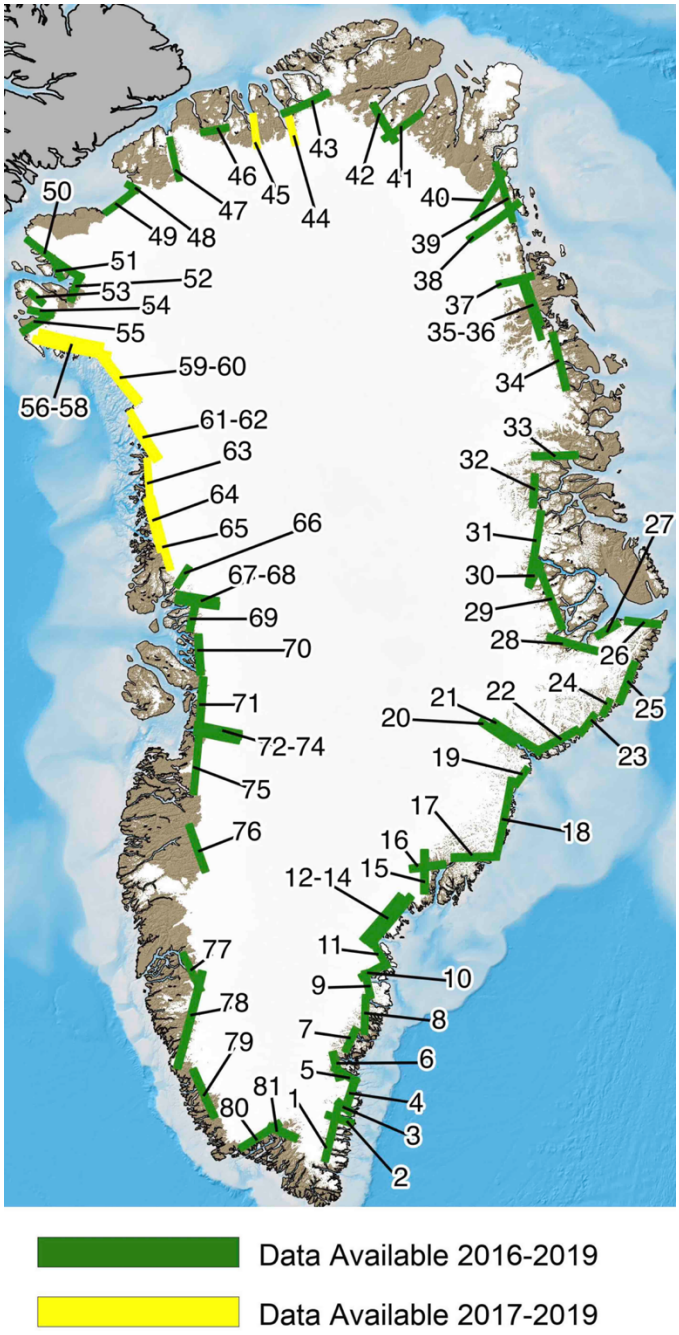

Figure 1: Swath locations and corresponding swath ID numbers for this L3 product.

Data Fields

Each DEM is provided with 10 fields: 2 pertaining to physical measurements (*elevation*, *geoid*), 3 for ancillary information (*elevation_standardDeviation*, *elevation_count*, *elevation_qualityFlag*) and 5 fields for coordinate information (*latitude*, *longitude*, *x*, *y*, and *projection*).

Physical Measurements

elevation

The elevation field contains elevation averaged in 50 m bins. The number of points within each bin as well as their standard deviation are provided in the ancillary layers *elevation_count* and *elevation_standardDeviation*, respectively. All elevation measurements are referenced to the WGS 1984 ellipsoid. For convenience, a geoid field is also provided to correct elevation measurements to mean sea level.

geoid

The geoid field is an estimate of the WGS 1984 ellipsoid relative to mean sea level, provided to reference the elevation measurements to mean sea level. To reference the elevation estimates to mean sea level, subtract the geoid field from the elevation field. The geoid is generated from the GOCO05c estimate provided at http://icgem.gfz-potsdam.de/calcgrid and is detailed in the following citation:

Fecher, Thomas, et al. "GOCO05c: a new combined gravity field model based on full normal equations and regionally varying weighting." Surveys in geophysics 38.3 (2017): 571-590.

Note: The GOCO05c geoid uses both satellite and terrestrial observations, and is one of many available geoid solutions. The GOCO05c solution was found to accurately reproduce mean sea level for swaths covering open ocean in several fjords around Greenland, and hence is the recommended correction for this elevation dataset.

Ancillary Fields

elevation_standardDeviation

The standard deviation of all L2 elevations within each L3 50 m grid cell.

elevation_count

The number of L2 elevations used to generate the L3 bin-averaged elevation.

elevation_qualityFlag

A quality flag based on 3 criteria:

1. the height above mean sea level
2. the standard deviation of points used in the averaging procedure
3. the number of points used in each bin.

The quality flag meanings are provided in the following table:

Quality Flag	Height Above Mean Sea Level	Standard Deviation of L2 Points in Averaging Bin	Number of Points in Averaging Bin
0	> -5	< 20	> 0
1	> -5	> 20	> 0
2	< -5	< 20	> 0
3	< -5	> 20	> 0
4	N/A	N/A	0

Large L2 data standard deviations (Flags 1 and 3) or very negative height above mean sea level generally indicate noisy L2 data.

L3 data with *elevation_qualityFlag*=0 are the highest quality. Consider masking L3 data with Quality flag values > 0 for more robust results.

Coordinate Fields

x,y

The *x* and *y* fields describe the horizontal and vertical coordinates, respectively, in the UTM projection pertaining to the center longitude of the swath (e.g. swath 63 is located in UTM zone EPSG:32621). The *x* and *y* coordinate arrays are one dimensional with lengths corresponding to the numbers of columns and rows, respectively, of the 2D fields.

projection

The projection field contains information related to the extent of the physical measurements and ancillary fields within the grid's UTM projection. These fields include *proj4text*, *GeoTransforms*, and other pertinent data to facilitate geospatial analyses in a variety of computational and mapping software systems.

latitude,longitude

The latitude and longitude at the center of the L3 grid cells are provided in the WGS 1984 (EPSG:4326) coordinate reference system. The latitude and longitude arrays have the same dimension as the physical measurement and ancillary information fields.

NetCDF file Format

NetCDF file names for this data set are of the form :

OMG_Ice_GLISTIN-A_L3_<time_coverage_start>_<index>.nc

where <time_coverage_start> is formatted as "YYYYMMDDhhmmss" and <index> is a two-character number that represents the flight line.

The data files are in NetCDF format and are compliant with the Climate and Forecast (CF) Metadata Conventions. The data file contains the following **variables** and **metadata**:

variables:

double ***elevation***(y, x) ;
elevation:_FillValue = 9.96920996838687e+36 ;
elevation:long_name = "Surface elevation relative to the WGS1984 ellipsoid" ;
elevation:standard_name = "surface_altitude" ;
elevation:units = "meters" ;
elevation:coverage_content_type = "physicalMeasurement" ;
elevation:valid_min = XX.X ;
elevation:valid_max = XXXX,X ;
elevation:coordinates = "latitude longitude" ;
elevation:scale_factor = 1L ;
elevation:add_offset = 0L ;
elevation:grid_mapping = "projection" ;
elevation:datum = "+ellps=urn:ogc:def:crs:EPSG::326XX" ;
elevation:comment = "Elevation is referenced to the WGS1984 geoid. To obtain height above mean sea level, use correction provided in the geoid variable." ;

double ***elevation_standardDeviation***(y, x) ;
elevation_standardDeviation:_FillValue = 9.96920996838687e+36 ;
elevation_standardDeviation:long_name = "Standard deviation of elevation measurements within averaging bin" ;
elevation_standardDeviation:standard_name = "standard_deviation" ;
elevation_standardDeviation:units = "meters" ;
elevation_standardDeviation:coverage_content_type = "auxiliaryInformation" ;
elevation_standardDeviation:valid_min = X.XXXXXXXXXXXXXXXXX ;
elevation_standardDeviation:valid_max = XXX.XXXXXXXXXXX ;
elevation_standardDeviation:coordinates = "latitude longitude" ;
elevation_standardDeviation:scale_factor = 1L ;
elevation_standardDeviation:add_offset = 0L ;
elevation_standardDeviation:grid_mapping = "projection" ;
elevation_standardDeviation:datum = "+ellps=urn:ogc:def:crs:EPSG::326XX" ;
elevation_standardDeviation:comment = "" ;

double ***elevation_count***(y, x) ;
elevation_count:_FillValue = 9.96920996838687e+36 ;
elevation_count:long_name = "Number of elevation measurements within averaging bin" ;
elevation_count:standard_name = "count" ;
elevation_count:units = "meters" ;
elevation_count:coverage_content_type = "auxiliaryInformation" ;
elevation_count:valid_min = X.X ;
elevation_count:valid_max = XXX.X ;
elevation_count:coordinates = "latitude longitude" ;
elevation_count:scale_factor = 1L ;
elevation_count:add_offset = 0L ;
elevation_count:grid_mapping = "projection" ;
elevation_count:datum = "+ellps=urn:ogc:def:crs:EPSG::326XX" ;
elevation_count:comment = "" ;

double ***longitude***(y, x) ;
longitude:_FillValue = 9.96920996838687e+36 ;
longitude:long_name = "longitude" ;
longitude:standard_name = "longitude" ;
longitude:units = "degrees_east" ;
longitude:axis = "X" ;
longitude:coverage_content_type = "auxiliary" ;
longitude:valid_min = XX.XXXXXXXXXXXXX ;
longitude:valid_max = XX.XXXXXXXXXXXXX ;

double ***latitude***(y, x) ;
latitude:_FillValue = 9.96920996838687e+36 ;
latitude:long_name = "latitude" ;
latitude:standard_name = "latitude" ;
latitude:units = "degrees_north" ;
latitude:axis = "Y" ;
latitude:coverage_content_type = "auxiliary" ;
latitude:valid_min = XX.XXXXXXXXXXXXX ;
latitude:valid_max = XX.XXXXXXXXXXXXX ;

double **geoid**(y, x) ;
geoid:_FillValue = 9.96920996838687e+36 ;
geoid:long_name = "GOCO05C Geoid - WGS84 Ellipsoid difference" ;
geoid:standard_name = "geoid_height_above_reference_ellipsoid" ;
geoid:units = "meters" ;
geoid:coverage_content_type = "physicalMeasurement" ;
geoid:valid_min = XX.XXXXXXXXXXXXX ;
geoid:valid_max = XX.XXXXXXXXXXXXX ;
geoid:coordinates = "y x" ;
geoid:scale_factor = 1L ;

geoid:add_offset = 0L ;
geoid:grid_mapping = "projection" ;
geoid:datum = "+ellps=urn:ogc:def:crs:EPSG::32624" ;
geoid:comment = "This field can be subtracted from the elevation field to obtain elevation referenced to mean sea level. Geoid correction is from Fecher et al 2017." ;

byte ***elevation_qualityFlag***(y, x) ;
elevation_qualityFlag:_FillValue = 4b;
elevation_qualityFlag:long_name = "Quality of average elevation from three criteria" ;
elevation_qualityFlag:standard_name = "quality_flag" ;
elevation_qualityFlag:units = "meters" ;
elevation_qualityFlag:coverage_content_type = "qualityInformation" ;
elevation_qualityFlag:flag_values = 0b, 1b, 2b, 3b, 4b ;
elevation_qualityFlag:flag_meanings = \
"elevation_standardDeviation<20;elevation-geoid>-5 \
elevation_standardDeviation>20;elevation-geoid>-5 \
elevation_standardDeviation<20;elevation-geoid<-5 \
elevation_standardDeviation>20;elevation-geoid<-5 \
elevation_count=0" ;
elevation_qualityFlag:coordinates = "latitude longitude" ;
elevation_qualityFlag:grid_mapping = "projection" ;
elevation_qualityFlag:datum = "+ellps=urn:ogc:def:crs:EPSG::32624" ;
elevation_qualityFlag:comment = "Recommended to use elevation_qualityFlag=0 for robust results." ;

string ***projection*** ;
projection:grid_boundary_top_projected_y = XXXXXXX.X ;
projection:grid_boundary_bottom_projected_y = XXXXXXX.X ;
projection:grid_boundary_right_projected_x = XXXXXX.X ;
projection:grid_boundary_left_projected_x = XXXXXX.X ;
projection:parent_grid_cell_row_subset_start = XL ;
projection:parent_grid_cell_row_subset_end = XXXL ;
projection:parent_grid_cell_column_subset_start = XL ;
projection:parent_grid_cell_column_subset_end = XXXXL ;
projection:spatial_ref = "PROJCS[\"WGS 84 / UTM zone XXN\",
GEOGCS[\"WGS 84\", DATUM[\"WGS_1984\", SPHEROID[\"WGS 84\",XXXXXXX,XXX.XXXXXXXXX,
AUTHORITY[\"EPSG\",\"XXXX\"]],
AUTHORITY[\"EPSG\",\"XXXX\"]], PRIMEM[\"Greenwich\",0,
AUTHORITY[\"EPSG\",\"XXXX\"]],
UNIT[\"degree\",X.XXXXXXXXXXXXXXXX,
AUTHORITY[\"EPSG\",\"XXXX"]],
AUTHORITY[\"EPSG\",\"XXXX\"]], UNIT[\"metre\",1,
AUTHORITY[\"EPSG\",\"XXXX\"]],

PROJECTION[\"Transverse_Mercator\"],
PARAMETER[\"latitude_of_origin\",0],
PARAMETER[\"central_meridian\",XX],
PARAMETER[\"scale_factor\",X.XXXX],
PARAMETER[\"false_easting\",XXXXXX],
PARAMETER[\"false_northing\",0],
AUTHORITY[\"EPSG\",\"XXXXX\"], AXIS[\"Easting\",EAST],
AXIS[\"Northing\",NORTH]]" ;
projection:proj4text = "+proj=utm +zone=XX +ellps=WGS84 +datum=WGS84
+units=m +no_defs" ;
projection:srid = "urn:ogc:def:crs:EPSG::XXXXX" ;
projection:GeoTransform = "XXXXXX.X XX X XXXXXXX.X X X" ;
projection:latitude_of_projection_origin = XL ;
projection:longitude_of_projection_origin = XXL ;
projection:scaling_factor = 0.9996 ;
projection:false_easting = 500000. ;
projection:false_northing = 0. ;
projection:semimajor_radius = 6378137L ;
projection:semiminor_radius = 6356752.3142 ;
projection:units = "meters" ;

double y(y) ;
y:_FillValue = 9.96920996838687e+36 ;
y:long_name = "Cartesian y-coordinate" ;
y:standard_name = "projection_y_coordinate" ;
y:units = "meters" ;
y:axis = "Y" ;
y:coverage_content_type = "coordinate" ;
y:valid_min = XXXXXXX.X ;
y:valid_max = XXXXXXX.X ;
y:comment = "Projected vertical coordinates of the grid" ;

double x(x) ;
x:_FillValue = 9.96920996838687e+36 ;
x:long_name = "Cartesian x-coordinate" ;
x:standard_name = "projection_x_coordinate" ;
x:units = "meters" ;
x:axis = "X" ;
x:coverage_content_type = "coordinate" ;
x:valid_min = XXXXXX.X ;
x:valid_max = XXXXXX.X ;
x:comment = "Projected horizontal coordinates of the grid" ;

Metadata:

Each data file also includes global metadata that further describe the product. These variables are as follows. Note: values containing "X" represent variables that differ based on swath

title = "OMG GLISTIN-A Elevation Data of Greenland Glaciers and Coastline" ;

summary = "Elevation measurements of the Greenland coastline measured by the Glacier and Land Ice Surface Topography Interferometer 2016-2019. These fields have been bin-averaged at 50m and reformatted to meet the specifications of the JPL PO.DAAC" ;

keywords = "Ice Sheet Elevation, Ice Sheet Mass Balance, Ice Sheet Measurements, Ice Sheet Thickness, Ice Sheet Topography" ;

keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science Keywords" ;

Conventions = "CF-1.7, ACDD-1.3" ;

id = "OMG_Ice_GLISTIN-A_L3" ;

uuid = " XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX " ;

naming_authority = "gov.nasa.jpl" ;

cdm_data_type = "Grid" ;

history = "GLISTIN-A elevation grid created by bin-averaging swath data from input product XXXXXX_XXXXX_XXXXX_XXX_XXXXXX_XXXXXX_XX_XX.grd at a 50 meter posting, and outputting to netCDF file format." ;

source = "Elevation data from the GLISTIN-A radar interferometer." ;

platform = "Gulfstream III" ;

platform_vocabulary = "GCMD platform keywords" ;

instrument = "Glacier and Ice Surface Topography Interferometer" ;

instrument_vocabulary = "GCMD instrument keywords" ;

processing_level = "L3" ;

comment = "Grid was generated using resample_pipeline from github/nasa/glistin. These open-source scripts can be used to generate similar grids at different resolutions." ;

standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention" ;

acknowledgement = "This research was carried out by the Jet Propulsion Laboratory, managed by the California Institute of Technology under a contract with the National Aeronautics and Space Administration." ;

license = "Public Domain" ;

product_version = "1.0" ;

references = "DOI:10.5067/OMGEV-GLNA1" ;

creator_name = "OMG Science Team" ;

creator_email = "omg-science@jpl.nasa.gov" ;

creator_url = "http://dx.doi.org/10.5067/OMGEV-GLNA1" ;

creator_type = "group" ;

creator_institution = "NASA Jet Propulsion Laboratory (JPL)" ;

institution = "NASA Jet Propulsion Laboratory (JPL)" ;

project = "Oceans Melting Greenland (OMG)" ;

program = "NASA Earth Venture Suborbital-2 (EVS-2)" ;

contributor_name = "Ian Fenty, Michael Wood, Brian Bachman, Matthew Gonzalgo, Forrest Graham, Yunling Lou, Delwyn Moller, Ronald Muellerschoen, Joshua Willis, Yang Zheng" ;

contributor_role = "principal investigator,author,author,author,author,author,author,author,principal investigator,author" ;

publisher_name = "Physical Oceanography Distributed Active Archive Center (PO.DAAC)" ;

publisher_email = "podaac@podaac.jpl.nasa.gov" ;

publisher_url = "http://dx.doi.org/10.5067/OMGEV-GLNA1" ;

publisher_type = "group" ;

publisher_institution = "NASA Jet Propulsion Laboratory (JPL)" ;

geospatial_bounds = "POLYGON((-XX.XXXXXXXXXXXXX XX.XXXXXXXXXXXXX, XX.XXXXXXXXXXXXX XX.XXXXXXXXXXXXX, XX.XXXXXXXXXXXXX XX.XXXXXXXXXXXXX, XX.XXXXXXXXXXXXX XX.XXXXXXXXXXXXX))" ;

geospatial_bounds_crs = "WGS1984" ;

geospatial_bounds_vertical_crs = "ESPG:XXXXX" ;

geospatial_lat_min = XX.XXXXXXXXXXXXX ;

geospatial_lat_max = XX.XXXXXXXXXXXXX ;

geospatial_lat_units = "degrees_north" ;

geospatial_lat_resolution = X.XXXXXXXXXXXXXXXXX ;

geospatial_lon_min = XX.XXXXXXXXXXXXX ;

geospatial_lon_max = XX.XXXXXXXXXXXXX ;

geospatial_lon_units = "degrees_east" ;

geospatial_lon_resolution = X.XXXXXXXXXXXXXXXXX ;

geospatial_vertical_min = X.X ;

geospatial_vertical_max = XXXX.X ;

geospatial_vertical_resolution = "0.2" ;

geospatial_vertical_units = "meters" ;

geospatial_vertical_positive = "up" ;
time_coverage_start = " XXXX-XX-XXTXX:XX:XX " ;
time_coverage_end = " XXXX-XX-XXTXX:XX:XX "
time_coverage_duration = " XXXXXXXXXXXXXXX " ;
date_created = " XXXX-XX-XXTXX:XX:XX " ;